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Compare The effectiveness of SSSC in Transmission network using PI and ANN control with POD Controller

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ABSTRACT

In this paper present the compare the effectiveness of SSSC in transmission network using PI and ANN control technique with pod controller. With the growing power demand, it is vital to expand power transfer capacity of transmission lines. But the new expansion in our present transmission system is confined due to financial problems, environmental concerns and health hazards due to electric and magnetic fields. May be its worthwhile option to use flexible AC transmission system (FACTS) for enhancement of power capacity of transmission system. This paper presents, fruitfulness FACTS device SSSC using ANN control technique with POD (Power oscillation damper) as additional controller. The major function is to decrease the peaks overshooting and clearing time of inter area oscillations, hence betterment in transient stability. The proposed neural network controller is capable of providing good dynamic performance compared to conventional Proportional integral (PI) controller. For the fulfillment of analysis, time domain simulation outcomes are correlated for results verification. This paper proposes modeling and simulation on MATLAB/Simulink Software for the proposed test system. Result displays that, power oscillation are rapidly damped than traditionally PSS by employing POD with FACTS- Controllers.

KEYWORDS: FACTS Controller, low frequency oscillation damping, MATLAB/ Simulink, POD, neural network controller, PI control.

1. INTRODUCTION

In present-day world, electrical power demand is increasing significantly over the last few decades. After all this growing rate of power demand does not pursue through the enrichment in power generating plants and transmission capacity. Thus in place of, to accommodate the increasing electric load requirement, power generation plants are operating at their maximum capacity Similarly transmission lines are also running nearer to their thermal limits. So, the power systems are seemly less sheltered and always carrying the exposure of voltage instability which has led to many major network collapses world-wide. As the electric power system was not so complicated in previous times, the major controversy was to damping the local area oscillations which were simply performed by the aid of AVRs .Then PSS appear which associated to the generators which present sizable concurrence towards the oscillations of the network. Hence traditionally PSS was employed for damping the local zones of oscillations in electric network. Different preventive measures as generation and transmission of energy adjourn, carrying reserve generators online, load curtailing and VAR back up by serial or parallel capacitors are followed to conquered voltage instability controversy. However, most of them are electromechanical controller which got the demerits like sluggishness, wear and tear. As an alternate key, intense consideration have been compensated to FACTS (Flexible Alternating Current Transmission System) devices which are directed from present-day components of power electronics, which could give active and reactive power accurately and keep the network stability limit. In present paper FACTS devices with additional controller is employed for damping the power network oscillations. Thus by employing POD-FACTS the network power oscillations can be quickly damped as related with another commonly devices. Since these controllers impact the driving voltage and thus the current and flow of power directly. For a given MVA size series controllers are manifolds robust than shunt controllers, in order to perform the desire functions such as to control the current/power flow and damping the oscillations. . This paper presents an analysis of an intelligent controller with neural network for SSSC by using pod controller.

The Static Synchronous Series Compensator (SSSC), one of the crucial FACTS device, subsists of a voltage-sourced converter (VSC) and a transformer linked in serial with a power line. The SSSC implants a voltage with changing magnitude in quadrature with the line current, hence mirroringan inductive or capacitive reactance. This mirrored changeable reactance in serial with the line hence has lever agence on transmitted electric power. Therefore SSSC control wide range of power through transmission line. The fundamental construction of an SSSC is shown in **Fig.1**.

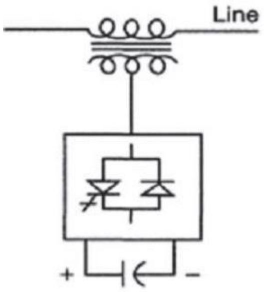


Fig. 1. Basic schematic of an SSSC

In order to give compensation by assuring a rise in the stability which in turn increases the flow of power and damped the power oscillations, the compensation techniques the devices alike SSSC with ANN and supplementary POD are employed. The switching converter employs self- commutating switches like GTO, IGBT. The switching converter sort has manifold merits like rapid response, desires lesser space, re-locatable and modular.

2. CONTROL BLOCK DIAGRAMS OF SSSC, PI , ANN AND POD

A.SSSC

The SSSC implants a voltage in serial with the line regardless of the line current. The SSSC can yield inductive and capacitive compensating voltage regardless of the power line current equal to the rated current of the line. In voltage compensation zone, the SSSC can keep the rated capacitive and inductive compensating voltage irrespective of the varying line current. The control scheme block diagram is denoted **in Fig.3**

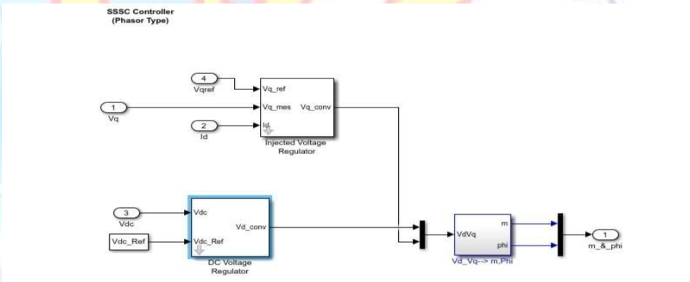


Fig. 2. Control Block Design of SSSC

B.POD

POD gives supplementary input signal to AVT for damping the network oscillations. Generally bus voltage, line current, real and reactive power from the bus are the enforced input signals [12]. For maintaining the damping, there is necessary for POD to give electrical torque component which is in phase to speed of rotor diversion (dÀ r).POD subsist of distinct blocks, gain block finds the magnitude of power oscillations confer to its gain value. Washout block shows high pass filter and assure at normal state outcome of POD is zero. Phase compensating block gives the adequate phase lead properties for compensating the phase lag betwixt the input of exciter and torque of alternator. Time constant block manage the proper time lag for controllers.

C. CLOSED LOOP CONTROL SCHEME FOR SSSC WITH NEURAL CONTROLLER

The control scheme proposed earlier is based on the line impedance control mode in which the SSSC compensating voltage is derived by multiplying the currentamplitude with the desired compensating reactance X qref. Since it is difficult to predict X qref under varying networkcontingencies, in the proposed scheme, the controller is modified as shown in fig. 2 to operate the SSSC in the automatic power flow control mode [6]. In this mode, thereference inputs to the controller are P ref and Q ref, which are to be maintained in the transmission line despite system changes.

The instantaneous power is obtained in terms of d-q quantities as,

P=3VdId/2 and Q=3VqIq/2

from equations required current reference are calculated as I d ref=2Pref/3Vd and I q ref=2Qref/3Vq

The line current I abc and the line voltage V abc are sensed at the point B2 on the transmission line of Fig. 1 and are converted into d-q components. The desired current references I dref and I qref are compared with actual current components Id and I q respectively and the error signals are processed in the neural controller. Initially PI controller is designed . Based on the controller parameters, the required small displacement angle β to control the angle of the injected voltage with respect to the line current has been derived. A Phase Locked Loop (PLL) is used to determine the instantaneous angle θ of the three-phase line voltage V abc. The current components I d and I q of the three phase line currents are used to determine the angle θ ir relative to the voltage V abc. Depending upon the instantaneous reactive power with respect

to the desired value either (π/2) is added (inductive) or subtracted (capacitive) with β. Thus, the required phase angleis derived as θ ref

= θ + θ ir + β ± (π/2) The modulation index m derived from the active power control part of the circuit andthe phase angle θ ref are applied to the PWM modulator to generate SSSC compensating voltage using θ ref and m, the fundamental component of PWM inveter output voltage is obtained in equation,

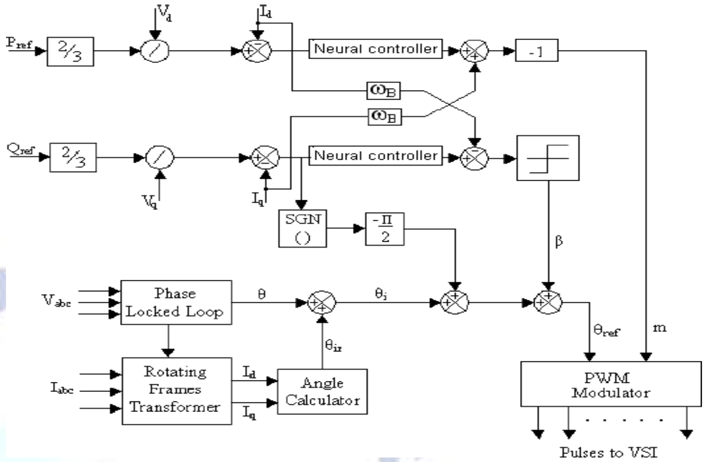


Fig.3. SSSC closed loop control scheme.

Since PI controller parameters are to be tuned and it is replaced with the neural controller. In the present work the input-output data necessary for the off-line training of theneural network have been obtained using voltage transfer ratioof the chosen SSSC Mean Square Error (MSE) is the performance criterion that evaluates the netw ork according tothe mean of square of error between the target and computed output. Learning occurs with a learning rate of 0.01 and momentum factor is 0.9.the hyper bolic tangent sigmoid (tansig) is used as the activate function. Trails have been carried out to obtain maximum accuracy with min neurons per layer. The simulink block diagram of neural controller

3. SIMULINK of neural controller

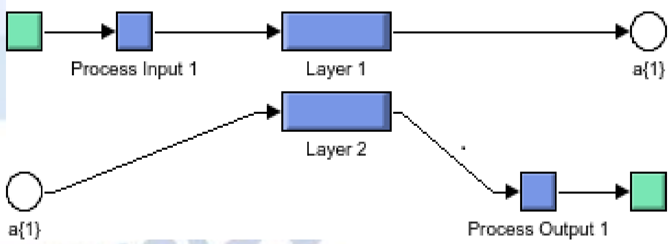


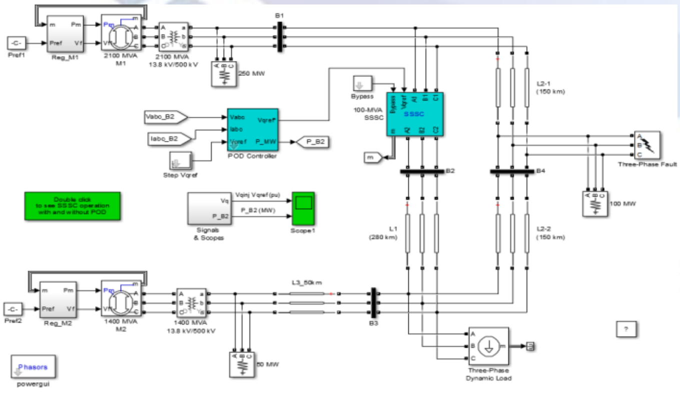
Fig.4.Neural controller

Fig.5. shows the simulink model of neural network controller. It consist of three layers .The layers are input ,hidden, output layers. This neural network can be replaced the position of PI controller in SSSC controller. The input of PI controller can be applied to ANN

controller input. The output of ANN V qref is given to SSSC.

SIMULINK MODEL DESCRIPTION

The power network subsists of two substations (M1 and M2) and one main load center at bus (B3). First power generating substation M1 is rated as 2100 MVA and it showing six machines with rating of 350 MVA each. The second one substation M2 is rated as 1400 MVA exhibiting four machines with rating of 350 MVA each. The load center near about 2200 MW is formed by employing a dynamic load model, where consumed real and reactive power by a load is a function of voltage of the network. The substation M1 is associated to this load with two transmission lines (L1 and L2). The length of line L1 is 280 km, where line L2 has length 350 km and it is divided into two segments of 150 km each so that to simulate a three phase fault (by employing a fault breake r) at the middle point of the line. The substation M2 is linked with the load through a 50 km line L3. With omitting SSSC, the f low of power approaching to this main load is pursue as: 664 MW flow of power measured at bus B2 on line L1, 563 MW flow of power measured at bus B4 on line L2, and 990 MW flow of power measured at bus B3 on line L3.The SSSC is rated as 100 MVA is placed at bus B1 in series with line L1 and it is able to implant up to 10% of the nominal network voltage. The reference implanting vol tage is intent by power oscillation damping (POD) controller whose outcome is linked with reference input voltage of SSSC. The volt age at bus B2 and current through a line L1 are the inputs of pod controller.



4. RESULT AND DISCUSSION

In the section the results got for proposed system are presented.

A.SSSC operation without fault

Fig shows the result of POD ON and OFF with PI and ANN CONTROLLER.The x axis of chart shows the simulation time And y axis depicted with Vqinj Vqref(pu) and power at bus B2[p_B2(MW)]. These below fig shows the SSSC operation without fault.fig.7 compare with fig 6 easily shown in graph the performance of sssc is improved both inductive and capacitive mode operation.

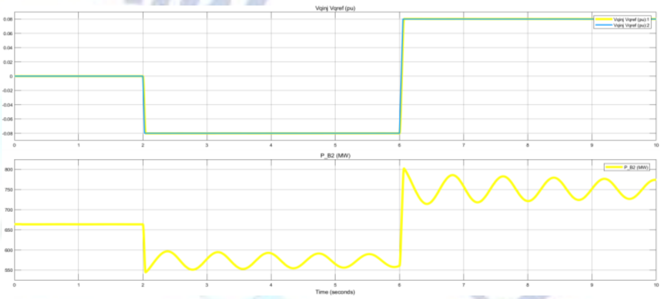


Fig .6. SSSC INDUCTIVE AND CAPACITIVE MODE WITH PI CONTROLLER WHEN POD OFF

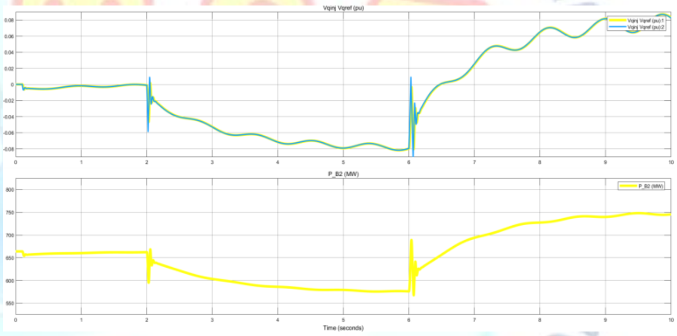


Fig.7. **SSSC CAPACITIVE AND INDUCTIVE MODE OPERATION WITH POD ON**

It is shows the simulation for both POD status OFF and ON with PI CONTROLLER.At 2sec is switched to inductive mode and at 6 sec to capacitive mode.it can be easily senn that there is a significance difference between oscillation damping for both cases.SSSC operation is therefore more efficient with pod controller.the below graphs shows the SSSC in inductive and capacitive mode op eration when pod OFF and ON with replacing the PI controller with ANN controller.it shows the more efficient results when compare with PI controller.

The damping oscillations of SSSC of PI controller when comapre with ANN controller reduced and system power quality at bus 2 is improved.these overall operation can be held on without enforcement of 3 -phase fault.the graphs shows the better response of PI controlled replaced by ANN CONTROLLER

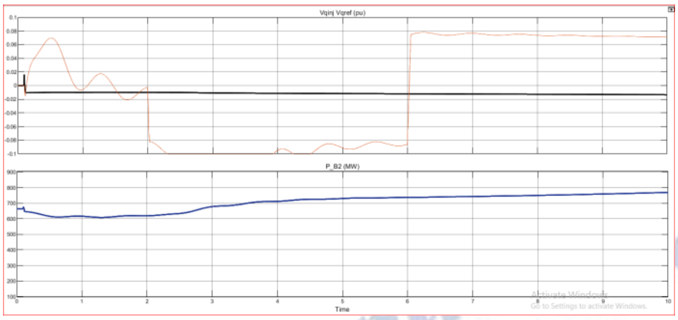


Fig.8. SSSC inuctive and capacitive mode of ANN controller with POD ON

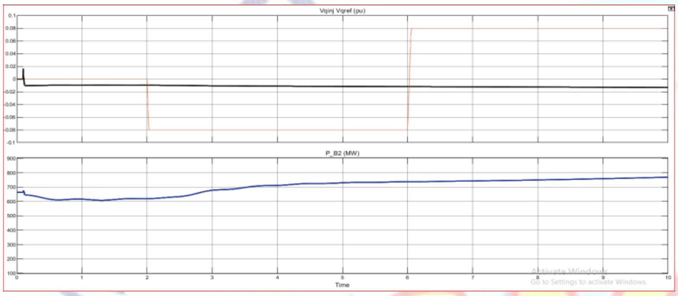


Fig.9.SSSC inductive and capacitive mode with ANN controller when POD OFF

B. SSSC OPERATION WITH FAULT

Below figure shows comparision of the SSSC in inductive and capacitive mode operation of using PI and ANN control technique with operation of POD controller. In the below fig shows that,a three phase fault is occurred at 1.33 sec.The fault duration is 0.166sec.after the fault the damping oscillations are reduced when compare with PI controller with ANN controller reduced.The oscillations are damped in less than second where as for operation without pod the power oscillations continue an d settling time is greater than 5 secondds.this paper also shows the SSSC with ANN is very useful to improve the transient stability.on graph X axis labeled with time and Y axis with power in MW at bus_B2

Fig.10.and fig.11. shows the SSSC in inuctive and capacitive mode operation with POD AND PI CONTROLLER.fig.12. shows the operation of SSSC in transmission network with POD and NEURAL CONTROLLER. The power at bus2 is improved by using NEURAL NETWORK .after the fault the voltage spikes at SSSC are reduced by replacing the PI controller with NEURAL NETWORK controller

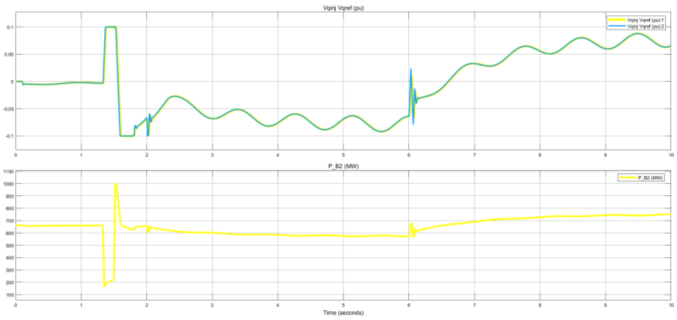


Fig.10. SSSC inductive and capacitive mode when POD ON using PI controller

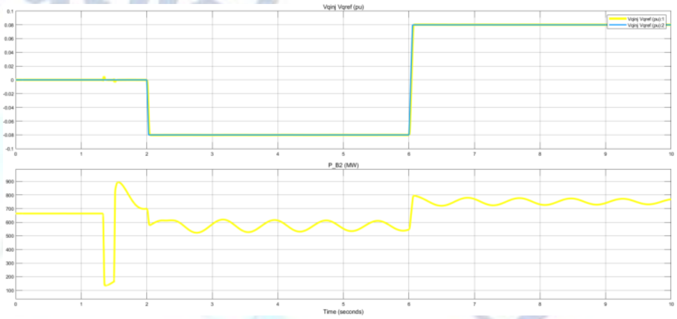


Fig.11.SSSC inductive and capacitive mode when POD OFF using PI controller

When PI controller replaced by ANN controller. after the fault the sytem power at bus 2 is improved and voltage oscillations are reduced
Fault occurrence – 1.33 sec
Fault duration is 0.166 sec
After the fault it can be recovered and circuit breaker closed.the power at bus 2 is improved and injected voltage at sssc is improved when compare with PI controller is replaced by ANN controller

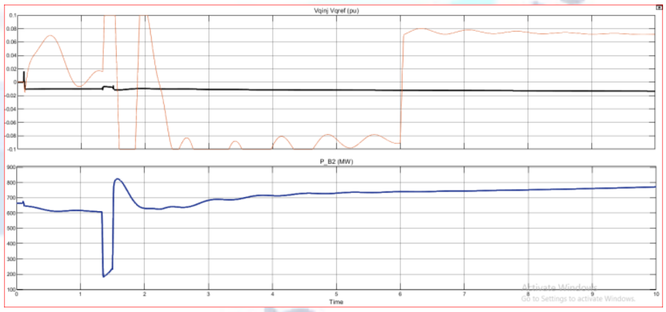


Fig.12. SSSC inductive and capacitive mode when POD ON using ANN controller

5. CONCLUSION

This paper presents The dynamic performance of SSSC is analysed with PI and neural controllers using Matlab/ Simulink. The enforced POD with NEURAL CONTROLLER gives stabilizing signals to the facts device. For the investigation of series FACTS-POD with NEURAL NETWORK ,a 3-phase fault is activated at time

1.33 sec having fault duration is 0.166 sec, results shows the SSSC with POD and ANN has superior potential for damping the network oscillations compared to SSSC with POD and PI controller. In addition SSSC- POD with ANN rises real power of the system , hence improving the load capacity of the network. Finally concluded that power oscillation damping of the network at bus 2 increased by employing SSSC-POD with additional ANN controller.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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